Report for 2004IL49G: Estimating shallow recharge and discharge in northeastern Illinois using GIS and pattern recognition procedure

There are no reported publications resulting from this project.

Report Follows

Problem and Research Objectives

The management of water resources requires quantifying the interaction between components of the hydrologic cycle, including the rates and variability of the recharge and discharge (R/D) to aquifers. These R/D rates define the relationships between the groundwater, precipitation, and surface water, and thus can restrict management options for water supply. The management of water resources in northeastern Illinois is complicated by interstate agreements, hydraulically coupled aquifer systems, natural and anthropogenic contamination, groundwater / surface water interaction, and conjunctive use of multiple resources. This research is developing a computer program implementing several methods of estimating and mapping R/D, apply the resulting software to improve the understanding of spatial variability of shallow R/D in northeastern Illinois, and thus address a research priority of national importance and of broad interest.

Methodology

The first task to be addressed is the development of a Pattern Recognition Utility (PRU) to identify recharge zones within noisy spatial data and estimate R/D rates for each zone. The PRU will be a graphical user interface (GUI) tool and compatible with ArcGIS 9 that implements several advanced image processing methods and couples these to the R/D estimation codes of Stoertz and Bradbury (1989), Bradbury et al. (2000), and Lin (2002). The software will be tested on a USGS internal project (Krohelski et al., 2003) in Wisconsin to determine trends (spatial and temporal) in recharge rates and investigate dominant recharge processes occurring in select undeveloped, agricultural, and urban watersheds.

After the software is successfully tested, the approach will be used to assist in the estimation and mapping of R/D for the groundwater models that are part of a water resources assessment for northeastern Illinois (Meyer et al., 2002). Previous studies for regional R/D in this region are limited and the software will be applied to estimate the R/D to the shallow aquifers within a much short preparation time than current methods.

Principal Findings and Significance

In the proposal, UCODE (Poeter and Hill, 1998) was the parameter estimation code to be used to calculate the parameter values that provide a best fit between simulated output and calibration targets measured in the field. Another potential parameter estimation code, PEST, has been under evaluation for this project since December 2004. Yu-Feng Lin attended a short course "Model Calibration and Predictive Analysis using PEST" hosted by USGS-WRD in Middleton, Wisconsin from April 4 to 7, 2005. PEST is a model-independent nonlinear parameter estimator developed by Dr. John Doherty. During this short course, Yu-Feng Lin had a special meeting with Dr. Doherty to discuss the application of PEST on this research project. The new features in PEST such as parallel processing, SVD assist and Pilot Points can provide better quality of model calibration than UCODE for this research. Further investigation is in progress and the possibility of applying PEST instead of UCODE is high.

Yu-Feng Lin also attended two ESRI ArcGIS 9 short courses: 1) Introduction to Programming ArcObjects with VBA (from November 15 to 19, 2004); and 2) Working With ArcGIS Spatial Analyst (from January 11 to 13, 2005). The programming development feature in ArcGIS 9 is

much more advanced than ArcGIS 8 (ESRI, 2001) which we proposed to use in our project proposal. The enhanced multi-language support (such as VB, C, C++ and Python) and Model Builder Platform will make the software development for this project more efficient. Therefore, ArcGIS 9 will be used for this project instead of ArcGIS 8.

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Literature Citations/References

Bradbury, K.R., Dripps,W., Hankley, C., Anderson, M.P., and Potter, K.W., 2000, Refinement of two methods for estimation of groundwater recharge rates, Final project report to the Wisconsin Department of Natural Resources, 84 pp.

Environmental Systems Research Institute (ESRI), 2001. ArcGIS User Guides – Bundle, Redlands, California: Environmental Systems Research Institute.

Krohelski, J.T., Hunt, R.J., and Gebert, W., 2003, Spatial and Temporal Shallow Recharge Rates in Wisconsin, U.S. Geological Survey internal project number: 2491-9KH38, US Geological Survey - WRD, Middleton, Wisconsin.

Lin Y-F., 2002, Development of a Digital Method for Estimating Groundwater Recharge and Discharge, Ph.D. Dissertation, University of Wisconsin - Madison, 106 p. (plus one CD-ROM).

Meyer, S.C., Walker, D.D., McConkey, S.M., Dey, W.S., B. Brandon, C., Abert, C.C., and Mehnert E., 2002, Water-Resources Investigations for Kane County, Illinois, Proposal to Kane County Development Department, Geneva, Illinois, Illinois State Water Survey and Illinois State Geological Survey, Champaign, Illinois, 55 pp.

Poeter, E.P., and Hill, M.C., 1998, Documentation of UCODE, A computer code for universal inverse modeling. United States Geological Survey, Water-Resources Investigations Report 98-4080.

Stoertz, M.W., and Bradbury K.R., 1989, Mapping recharge areas using a groundwater flow model – a case study, Ground Water 27 (2), p. 220-228.